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Across Papaqueria



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ACROSS PAPAGUERIA.

BY
D. T. MACDOUGAL.
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ACROSS PAPAGUERIA.

BY

D. T. MACDOUGAL.

The Pacific coastal desert of North America extends from the region of the isthmus of Tehuantepec northward to include the peninsula of Baja California and a part of Upper California. To the eastward one broad arm spreads out from the shores of the Gulf of California to include nearly all of Sonora, the southern and western part of Arizona and the southern part of Nevada, in which regions it joins the higher bolsons, mesas and basins of Chihuahua, New Mexico, Utah, Nevada and California. The entire region is one of great aridity, and probably no part of it under 4,000 feet in elevation receives more than 12 inches of rainfall annually; the ridges and peaks which rise above this level may have three times as much, by the condensing action of their summits. On the other hand, the great area lying to leeward of the main peninsular ridge of Baja California and its northward continuation in California, are so situated that the annual precipitation is often as low as $2\frac{1}{2}$ inches per year, while many localities receive no rainfall over periods as long as eighteen months, as noted by Palmer with regard to the Raza islands in the Gulf of California.

No adequate natural history survey has yet been made of any portion of this region. The Boundary Survey Commission traversed the northern part in demarking the southern line of Arizona, the most arbitrary and meaningless political boundary in America, and made collections in the immediate vicinity of the line, but the nature of the work did not permit any attempt at studying the general relations of the life of the region, although much detailed information was procured as to the composition of the fauna and flora.

In the preparation of a *résumé* of "The Botanical Features of North American Deserts" (Publication No. 99, Carnegie Institution of Washington) it became apparent that systematic information on the general features of this region was very meagre, and an expedition from the Desert Laboratory was planned which would traverse a route from Tucson to the Gulf.

Tucson occupies a position on the eastern part of the great flattish ridge which slopes from elevations of three to four thousand feet in southeastern Arizona, westward to the delta of the Colorado River and the upper part of the Gulf of California. A score of mountain ranges, including the Whetstones, Santa Ritas, Santa Catalinas,



FIG. 1.—PORTION OF PAPAGO VILLAGE OF QUEROBABI.

Tortolas, Tortolitas, Sierritas, Tucsons, Carobabis, Baboquiviris, Quijotoas, Ajos, Growlers, Rincons, Dragoons, Mohawks, Gilas, Tules, Lechuguillas, Maricopas, Ciprianos, San Franciscos and San Rosarios, run transversely across the ridge with crests that rise to over 9,000 feet in some instances, the intervening valleys being for the most part broad, flattish troughs, with undeveloped drainage, opening to the northward into the Gila River and to the southward to the Altar and Sonoyta rivers in Sonora.

The greater portion of this ridge has been occupied by the Papago Indians, since they became differentiated from the Piman stock, per-

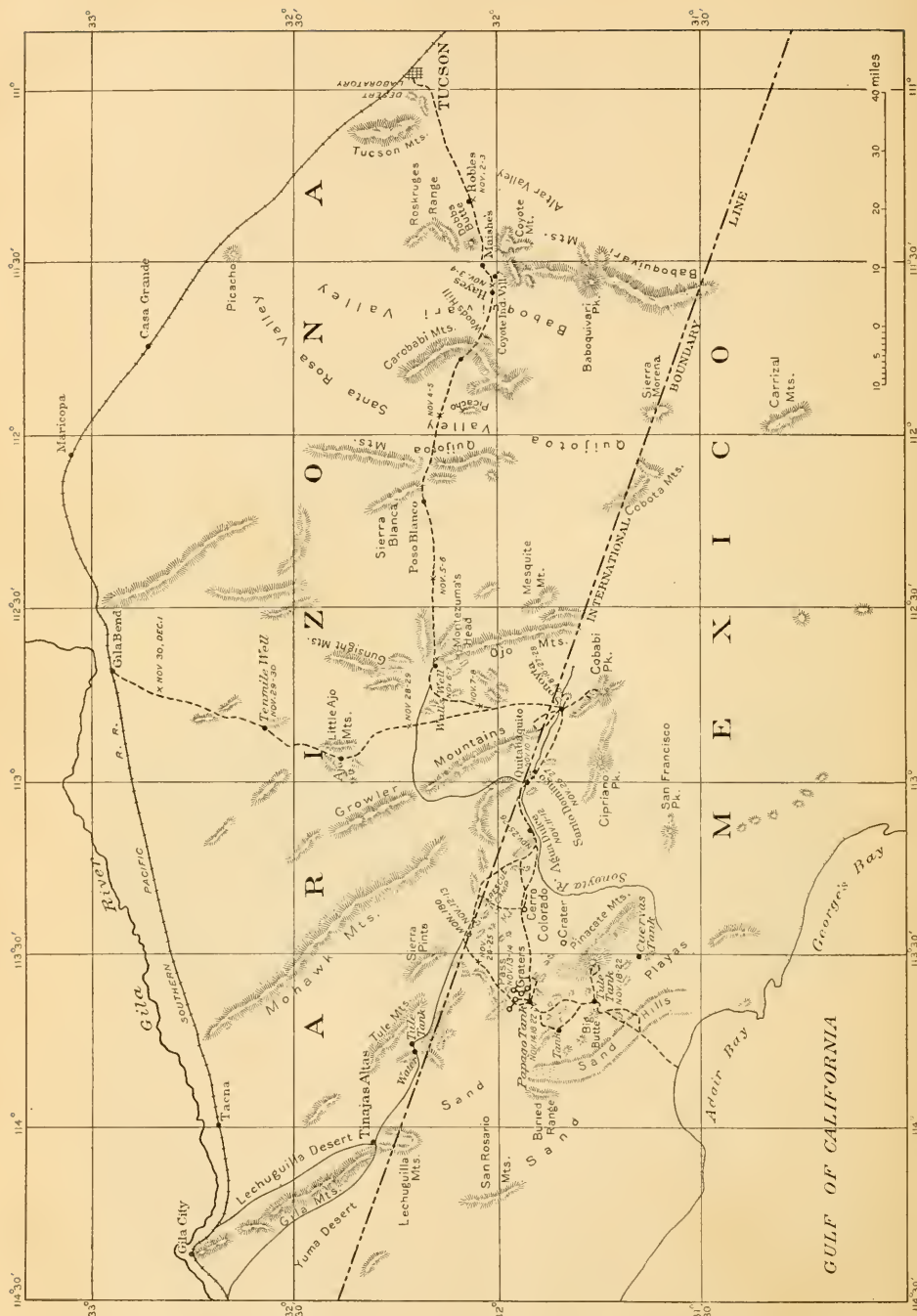
haps ten or twelve centuries ago, this tribe being first encountered by the Spanish of Coronado's expedition in the middle of the 16th century. The region became known as Papagueria and was traversed in many directions by zealous padres establishing missions and *visitaciones*, one of which, the famous San Xavier, survives to this day. The Indian still occupies the country as a whole, very much as he did at the advent of the Castilian, and his relations to the climate and the desert conditions, as revealed by various anthropological investigations, are as interesting, biologically, as anything to be encountered by the naturalist.

The expedition from the Desert Laboratory included Dr. W. T. Hornaday of the New York Zoological Park, Hon. J. M. Phillips of Pittsburg, Mr. Godfrey Sykes of the Desert Laboratory and the writer. Modern Tucson occupies the site of a frontier settlement of Papagueria, the mountains within sight across the plains to the northward and eastward being anciently held by hostile tribes. The crest of the high black hill, Tumamoc, on the west side of the Santa Cruz River, is occupied by the remains of a village, the double and triple walls surrounding it on the precipitous slopes giving it secure protection. These walls in part accentuate the serrated effect of some of the profiles and doubtless helped to suggest its Papago name, which means "the horned toad hill."

We were to follow the main trail from northeastern Papagueria to the salt beds on the shores of the Gulf of California near Adair Bay. A pilgrimage to these deposits became a matter of great economic and ceremonial importance in comparatively recent times, and salt brought from them is still occasionally offered for trade at outlying ranches. In addition to this historical interest, the general features of the fauna and flora promised evidence upon the major problems of habit and distribution of desert forms. Some of these reach their limit of occurrence on the slopes of the Santa Catalinas near Tucson and range southward and westward in Sonora between the mountains and the Gulf in such manner that the trip would make a complete section of their ranges.

The route followed the main height of land at elevations of 2,000 to 2,800 feet for a distance of 125 miles almost due west from Tucson until the northern end of the Ajo mountains was reached, when a sharp turn to the southward was made which soon took us out of the Gila drainage to that of the Sonoyta. This stream was first encountered south of the International Boundary near Monument 167 and about three miles east of the village of the same name.

The half dozen ranges encountered were traversed by low passes



MAP 1.—SKETCH MAP OF PINACATE REGION, ROUTES TRAVELLED INDICATED BY BROKEN LINE, *Compiled by Godfrey Sykes.*

of easy grade, and in the approaches a few wells have been dugged and walled by the Government, but as they are not suitably guarded or cleaned it is quite as well for the comfort of the traveller that their depth prevents a view of the water and its contents, which often smell vilely when brought to the surface. In one, the badly disintegrated remains of rattlesnakes and other animals were found, and all of the water on this portion of the route except that within 25 miles of Tucson, was bad and perhaps dangerous, although no ill effects were experienced by any member of our party.

THE OASIS OF SONOYTA.

The general structure of the oasis of Sonoyta is fairly representative of such formations in American deserts, and its principal features merit description. A great ovoid plain, forty or fifty miles across, lies mostly south of the International Boundary, with its narrower and lower portion to the westward. The plain, once a basin-like valley, is now filled with detritus from the encircling mountains to a depth of a few hundred feet. The greater part of the precipitation here and on the slopes of the neighbouring mountains sinks down in this broken material, forming running streams on the surface only during seasons of heaviest precipitation. The water percolating through the detrital mass gradually makes its way toward the lowest part of the original valley, this being facilitated, perhaps, by layers of clayey material or hard-pan impervious to water, with the result that in following these gently inclined strata it is brought to the surface by various converging lines of drainage at the lowest part of the gravel-filled valley within a mile of the International Boundary. The stream formed flows along over the margin of the clayey layer, being exposed to enormous evaporation, and furnishing a surface supply which may be led out in conduits for irrigation purposes. Further down it encounters the sand or gravel beneath the clay and again sinks into the ground. In the brief seasons of flood the stream may run far down before it is swallowed by the porous sands, and as aridity increases the end of the water recedes far upstream. It is this short reach of living stream that forms the heart of the oasis, nourishing, as it does, a vegetation widely different from that of the surrounding desert and affording conditions for the cultivation of food-plants for the human animal. The oasis of Sonoyta has, doubtless, been the site of a cluster of habitations since the beginning of agriculture, and has been known to the Papagos for a thousand years by this name, meaning the place where corn (sonot) will grow. Very naturally, the upper

part of the oasis has the surest supply of water, and the steady population of about 150 people have shifted about in accordance with the changes in the stream and alterations in the irrigation systems. The lower, uncertain part of the stream, with its precarious conditions, has been the scene of hunter's camps and sporadic ventures with small flocks, the oft-recurring seasons of extreme drought discouraging any more serious operations.

Thus the records show that in the early nineties, the entire population was centered about the Hacienda Santo Domingo midway of the oasis, but at the time of our visit the village of Sonoyta, at the



FIG. 2.—SONOYTA RIVER, NEAR THE VILLAGE OF THE SAME NAME.

head of the living water, was the centre of activity, the Mexicans, perhaps 75 in all, being accommodated here in characteristic adobe dwellings, while smaller clusters of wattled houses of the Papagos were scattered along the valley and down the stream for five or six miles. The Mexican *alcalde* and the “Jacke” (pronounced “Hacke”) or “*gobernador*” of the Papagos being the only recognized officials and administrators of civil law.

The old Hacienda of Santo Domingo, with its desiccated groves of fruit trees and grapes, ruined buildings and dismantled *arrastra*, presented a melancholy picture, although it was well understood

that the diversion of the waters of the oasis down to this point would practically restore it in a single season.

In the lower part of the oasis the streamway bends to the northward to within a short distance of the International Boundary, and near here, at Quitovaquita, a group of small springs ooze from the hillside a few feet north of the boundary line, and in flowing down to the lower ground their waters serve to irrigate a small field on the Mexican side. A single American had sought this refuge for the sake of the produce of the small field and of the small flock of goats which he tended.

The ancient road from Sonora coming through Altar and Caborca led through the oasis of Sonoyta and across the desert to Altar, California, crossing the Colorado River at Yuma. In the earlier days it was much traversed by Spanish priests and the guards for the missions, this route having been followed by Father Kino as early as 1699, and soon became known as a "Camino Real." Later, especially during the rush to California consequent upon the discovery of gold, it was attempted by many inexperienced in the rigours of desert travel, and the long arid stretches between Sonoyta and Yuma became the scene of scores of tragedies, as evinced by the numerous crosses of stones which are thickly strewn along the way, especially in the vicinity of the Tinajas Altas, a series of kettle holes high up on the granite, containing the only supply of water in a three-days' journey. Naturally enough, the way became known as the "Camino del Diablo."

Within a few minutes after our arrival in Sonoyta we learned that a party of six Japanese had come up through Altar and Caborca and had evaded the immigration guard at the oasis, going out over the old desert highway across the border to gain the freedom of the United States. Disaster was quickly encountered, and two of the party returned for water and help which was freely given by the natives. Again they made the trial, passing our camp by a detour in the night. A day later we encountered one on the desert, worn and exhausted, who intimated by signs that he and a companion had become separated from the remainder of the party and that his friend lay ill in a distant copse along the streamway of the Sonoyta. Supplies were furnished him and upon our return a few weeks later these two had made back to Sonoyta to recuperate from their struggle, while the fate of the remaining four remains unknown. The tangents are long from water hole to water hole and their end might remain undiscovered for a decade, although one would preferably hope that such endurance and determination might win a refuge.

Barley, wheat, corn, melons, figs, beans, and grapes are grown by the holders of water privileges in the oasis, but in quantities barely sufficient for the needs of the inhabitants. Some foodstuffs, including sugar and grain, are brought in from the outside. The small fields with their crops of introduced plants formed a striking contrast with the native vegetation fringing the streamway and the xerophytic forms of the adjoining desert. A heavy growth of mesquite (*Prosopis velutina*) occurs in places, the arrow-weed "cochinilla" (*Pluchea sericea*) inhabits plots of alluvium in the bottoms, while the batamote (*Baccharis glutinosa*) is taken by the Mexicans to denote places at which good water may be obtained by digging. The oasis is remarkable in the fact that it furnishes conditions which bring together three species of Parkinsonia (*P. aculeata*, *P. microphylla* and *P. torreyana*). An elder tree (*Sambucus glauca*) is represented by some large specimens. *Acacia greggii* is abundant, while the spiny smoke tree, or indigo tree (*Parosela spinosa*), occurs in the lower part of the oasis growing out in the gravelly flats in streamways, as it does in the Salton basin. A willow and a poplar are comprised in the larger growths of the oasis.

For a long period of years the oasis has practically been a free zone into which the products of Mexico and United States have been admitted, except for occasional application of customs regulations by visiting customs officials of Mexico. Official sanction for taking our large amount of equipment across the frontier into and out of the oasis into the country to the southward at this point was not easily brought about, however, and some intervention by President Roosevelt and Secretary Root was necessary to secure arrangements by which we were given the desired permission. This entailed the presence of a Mexican customs official, and Teniente Jesus Medina, with a detail of four privates from the Guardia Fiscal, marched from La Osa, a hundred miles to the eastward, to *visé* our papers and receive us into Mexico. This service was tactfully carried out, and, by engagement, Lieutenant Medina returned to Sonoyta two weeks later to render any aid necessary to the return of the expedition across the boundary, and give us full clearance.

During our stay of two days at Sonoyta some progress was made in the geographical work of the expedition. Southward from the oasis lies the Cobabi Range, the culminating peak of which has been, and is still given on the U. S. hydrographic charts as 9,457 feet. A visit to the summit was made by Mr. Godfrey Sykes, who made the height as 4,325 feet, and, as the aneroid carried was tested before and after the ascent, this elevation is probably very nearly correct.

FROM SONOYTA TO PINACATE.

Recruiting the expedition to a strength of nine men and seventeen horses, a start was made down the Sonoyta Valley on November 10th, being stopped by the Sonoyta itself, which rose in flood as a result of rains in the Cobabi and Cipriano mountains, and subsided so quickly that it had only the volume of a streamlet on the following morning. We were now following the old Camino Real or "Camino del Diablo," a route which has been traversed by survey parties of the boundary commissions and other expeditions. The flood water had carried the stream a dozen miles below Agua Dulce, where a



FIG. 3.—SINK OF THE SONOYTA RIVER BELOW AGUADULCE.

stop was made before starting to negotiate the long, waterless stretch westward to the Tule Desert. Upon our return the stream was found to sink three miles below at the Salada, which is over a mile in length and includes the low alluvial flats bordering the streamway.

Here, as in similar spots in this region, were found growing patches of salt grass (*Distichlis spicata*), salt bush (*Atriplex*), mesquite (*Prosopis*), and many plants of *Wislizenia* with bright yellow flowers.

Our Mexican scout explained that water reappeared at a place

lower down the courses of the river, at a place known as the "Bata-motal" (the place where the batamote, *Baccharis*, grows), at which place it is much less highly charged than here, and is drinkable.

At this and other camps in the arid southwest, many opportunities have been found to make observations on the ends of the currents of desert streams in sinks and playas. The lessened evaporation gives the attenuated current greater volume during the night, and an increase is visible within an hour before sunset, while by morning small streams coming out of mountain cañons will be seen to make out a distance of a hundred yards farther than in the daytime, before sinking in the sand.

While the wagons were being taken along the Camino del Diablo to the Tule Desert, a number of the party made a detour to the southward to examine a huge cinder cone, with a large and perfect central crater, known as the Cerro Colorado, that lies 12 miles east from Pinacate. Around its northern base is a great undrained area or playa, which accumulates considerable water in times of precipitation and bears a heavy crop of Indian wheat (*Plantago aristata*), upon which antelope were feeding. The base of the Cerro Colorado is fringed with a wide sloping zone of ash and fine cinder, suggestive of comparatively recent activity.

A temporary supply of water, which had vanished a fortnight later, was found in depressions in other playas near Monument 180 on our advance trip, and from a camp here the route was laid to the southward to gain the western slopes of the Pinacate Mountains proper.

Progress now became somewhat more difficult. Slopes of rough lava and great stretches of *malpais* were interspersed with ridges and ranges of granite of varying height. Among these a route was found to within a mile of one of the largest outlying sunken craters of the group. Numerous flattish dunes and drifts of sand were also encountered. South of Monument 180, a distance of about 20 miles, a level pass was found leading directly in to the volcanoes. To the right or westward of the pass were the irregular slopes and jagged summits of a small granite range, which rose abruptly from the plain on all sides and which we named the Hornaday Range, in recognition of the work of Dr. W. T. Hornaday, who travelled completely around them in company with the author and made an examination of the fauna.

The Pinacate volcanoes might be enclosed in an oval figure, 60 miles in length and half that width, with its long axis running from southeast to northwest, lying directly inland from Adair Bay, from

which the culminating peak is about 32 miles distant. The ascent of the main peak was made on November 20 by five members of the party and a record left in a cairn on the summit. A count made of the cones and craters within a limited section of the region which could be seen clearly on the hazy day on which the ascent was made justifies the estimate that at least 500 cones and craters in various states of preservation were included in the Pinacate volcanoes. Pinacate reaches an elevation of 4,060 feet, and the summit represents the eastern half of one of the largest craters, while around it in all directions lie other cinder cones, the slopes of which have the maxi-

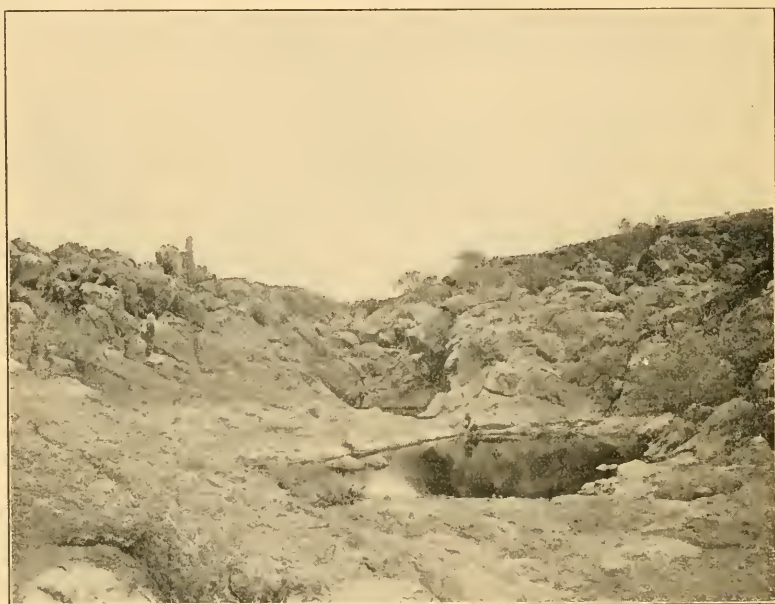


FIG. 4.—PAPAGO TANKS IN PINACATE MOUNTAINS.

mum steepness permitted by the character of the cinder of which they are composed. Work on these slopes was accomplished with no little difficulty. In addition to the laboured climbing in the sliding ash, this material afforded suitable conditions for *Opuntia bigelovii*, and the climber might by a slight slip find himself precipitated into a clump of it, with consequent discomfort or even serious danger.

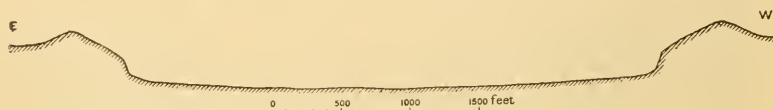
The secondary peak of the range, also a fragment of a huge crater, lying to the southeast of the main cone and but slightly less in elevation, was designated as Carnegie Peak by the members of the expedition. (See map 2.)

On November 14th, the expedition traversed an extensive plain made up of the gentle detrital slopes from encompassing granite ridges, worn down nearly to base level and bearing great stretches of galleta grass and creosote bush, over which roamed numbers of wild horses. The close of this day's journey found us camped in Mac-Dougal Pass, which separates the Hornaday Mountains from the main volcanic formations of the Pinacate volcanoes to the south-eastward. On the following day the resumption of the march brought us within three miles of a field of lava impassable with vehicles, but within easy reach of some of the more interesting topographical features of the region. Here the wagons were unpacked, the equipment assorted, and a selection necessary for further work was carried in on pack saddles to the Papago tanks. These tanks are a series of kettle holes in the granite, laid bare by erosion of a streamway carrying the drainage of enclosed valleys in the northern part of the Pinacate volcanoes. The tanks contained a few thousand gallons of water in the aggregate and are probably never totally emptied, though the level of the water was perceptibly lowered by the draft made on them during the fortnight of our occupation. These tanks are the most reliable source of water in the northern section of the volcanoes, and after they are passed the explorer must proceed to the southern end of the range to the Cuervas tanks, or to the Chives tanks, although we found a plentiful supply in the Tule tanks, 18 miles to the southward.

Abundant indications of former occupation by Indians, probably of Piman stock, are found. Near all of the water holes are numerous mealing holes, which by their depth testify to long usage, while converging trails are plainly marked in the lava and granite, those coming into the Papago tanks being worn to a depth of over a foot in places. A second convergence is to be noted of ancient highways which lead to the salt deposits on the shore of the Gulf, near the northern end of Adair Bay. The region of the volcanoes around the water holes and including the salt beds appears to have been most recently occupied by a section of the Papagos known as the Areneros, who seem to have been much more devoted to hunting than their agricultural relatives to the eastward and northward, and whose aggressive qualities led them into much trouble with their Mexican neighbours and Indian relatives. The entire region has been evacuated by them, however, and, except for an occasional pilgrimage to the salt beds, the water holes are entirely unoccupied.

CRATERS OF PINACATE VOLCANOES.

The northwestern part of the Pinacate region which we had entered is characterized by great sunken craters, the rims of which lie but little above the level of the surrounding lava slopes of older formation. Three of these were examined with some care. One of the largest lies almost due south from the pass at the east end of Hornaday Mountains, and has a diameter of about 1,200 yards at the bottom, with almost vertical walls going down 400 feet. So far as our examination could be depended upon to yield an accurate interpretation, this crater had thrown out cinder and mud at various times, as evinced by the deposits on the plain around its rim. The walls showed granite strata and various lava deposits from older volcanoes. The rim had been eroded down at a few places and the detritus carried by small streamways toward the centrum of the floor. The larger and more striking plants had arisen along these small streamways, thus having the appearance of radiating from the central portion toward the rim. Among these were the sahuaro,



PROFILE 1.—MACDOUGAL CRATER, 400 FEET IN DEPTH.

ocotillo, galleta grass, dodder, *Parkinsonia*, ajo, *Hibiscus*, *Tribulus*, *Pectis*, golondrina (*Euphorbia*), *Dalea* and *Amarantus*. The soil in the extreme lowest part of the crater was distinctly moister, and here the herbaceous forms mentioned grew very densely, making a distinct patch that forms a marked feature when viewed from the rim.

The Molina crater, which lies two miles to the eastward, likewise has its rim but little above the surrounding lava beds, its name being suggested by its form, being, in fact, composed of three craters, the intervening walls having been carried away to give the aggregate a trifoliate form.

Sykes crater, 3 miles north of Papago tanks, has built up a rim on the stratified material through which it penetrates, so that it has a depth of 750 feet. The walls are so little broken that in only one place has a slide been formed, down which a descent may be made. Mr. G. Sykes made the descent and obtained the measurements and material described and his name has been applied to the crater. *Encelia*, *Sphaeralcea*, *Nicotiana*, mesquite, *Baccharis*, palo verde,

Covillea, sahuaro, galleta grass and Bigelow's opuntia were found on the rough floor of the crater, the bowl of which has a diameter less than twice its depth, and hence presents the most imposing appearance of any that were visited. Here, also, the product of eruptions included both cinders and mud of comparatively recent date.

To the westward of Sykes crater lies Phillip's Butte, which rises directly from the crater with which its slopes are continuous and reaches an elevation of about 1,500 feet.

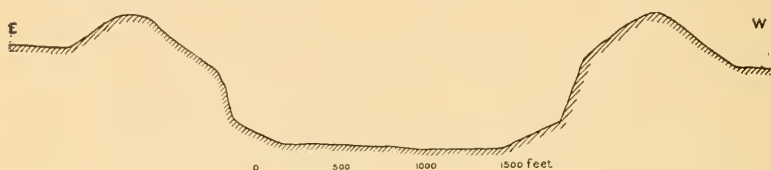
In order to make the ascent of Pinacate and visit the shore of the Gulf, five members of the party left the main camp at Papago tanks and proceeded with a pack outfit to Tule tanks, 18 miles to the southward. Bands of antelope were encountered on the intervening slopes, while the entire region contains numbers of bands of mountain sheep



FIG. 5.—SYKES CRATER IN PINACATE MOUNTAINS.

(*Ovis canadensis*). The sahuaro, *Covillea* and an *Ephedra*, as well as a prickly pear, are found near the summit of Pinacate and collections were also made, including *Eriogonum*, *Perityle*, *Monardella*, *Verbena*, *Sympetala rupestris*, *Groton*, *Euphorbia*, and a few others, the identity of which is not yet known. Mr. G. Sykes marched from the camp at Tule tanks to the shore of the Gulf and returned, a total distance of 42 miles, in one day, extending the line of our inspection to sea-level, and allowing opportunity for the correction of aneroids. The shore near Adair Bay is fringed with wide flats nearly bare, which are partially submerged at the highest tides. Above this is a belt 3 to 5 miles in width, in places covered with a dense growth of galleta grass, beyond which lie the great ranges of sand dunes, piled up to a height of 80 to 100 feet in places, making a zone several miles wide. The streamways from the slopes come directly

against the upper side of these dunes and repeated floods have carried down material which has been spread out to make broad playas at these places. Such a termination is reported of the Sonoyta River, although not actually observed by any member of our party. This river during the season of greatest floods makes to the eastward and



PROFILE 2.—SYKES CRATER, 750 FEET IN DEPTH.

in a southerly direction past the Pinacate volcanoes, and then veers slightly to the westward, coming against the dunes south of the main peak, and sharing the fate of the lesser streams. Previous visitors to contiguous regions have described the Sonoyta as going around the north end of the range, a statement now corrected for the first time.

FEATURES OF THE VEGETATION.

The region traversed by the expedition might be properly termed the northernmost portion of the desert which extends southward along the Pacific coast to the Isthmus of Tehuantepec. The precipitation is less than a dozen inches, except on the higher summits, the greater part of the yearly rainfall coming in midwinter and midsummer. Temperatures of 118° and 120° F. have been recorded in the lower levels, some places showing a daily maximum during portions of six months of every year. The possible evaporation that would ensue from a water surface on the plains would probably be between 70 and 80 inches per year, or about six to eight times the precipitation. The general aspect of the vegetation is highly xerophytic, although of some abundance. An analysis of the flora, however, shows that a large proportion of it, as in all western American deserts, is made up of annuals and perennials which are active only during the periods of maximum precipitation in summer and winter. These forms do not exhibit any structures which distinguish them from mesophytic species of moister regions, but they have peculiar rhythms and dormancies. The seeds of many of the winter annuals will germinate only in the low temperatures of the winter months, lying wholly inactive during the summer rains, while the summer annuals are equally unaffected by the moisture and stimulus of change

of the cooler months. As a result of the arrangements in question, the vegetation shows an intricate interlocking of temperate and sub-tropical forms with, of course, a very large number of endemic species of both classes. Legumes are abundant and are represented by a great number of forms. Most remarkable of all, however, are the cacti, a group of comparatively modern origin, and including hundreds of species, some of which are extremely restricted in distribution.

Of these, the sahuaro, or giant cactus (*Cereus giganteus*) is probably the most prominent by usefulness and obtrusiveness of all the striking forms that inhabit the desert land of the Papagos. It ranges from the Tonto basin in central Arizona westward to the Colorado River, which it crosses to occupy a small area in California in the vicinity of the mouth of the Bill Williams River. It extends to the eastward to the drainage of the San Pedro River and southward in Sonora to the latitude of Guaymas, its exact southern limit not being determined, and follows close to the Gulf up to its head. In the northern portion of its range it occupies sunny slopes at an elevation of 4,000 feet and it descends into some of the old craters of the Pinatecate volcanoes to a point but little above the sea-level, climbing the main peak near by to the maximum elevation. As the limits of the range of the sahuaro are approached, branching becomes less profuse and the outlying individuals show simply columnar trunks, usually showing some marks of the stress under which they exist. In more favourable localities an unending variety of grotesquely arranged branches is to be seen and secondary branches are exhibited in some instances. Native guides are given to informing travellers, with apparent sincerity, that the branches are in reality separate plants which have risen from seeds deposited in cracks of the trunk by woodpeckers and other birds. It has been pointed out recently (Turrell, C. A., *Univ. of Ariz. Monthly*, Jan., 1908) that the name for the great tree cactus (*Cereus giganteus*) must have been a Castilian rendering of an ancient name in use when the Spanish explorers first came, and as the use of the *g* with the sound of *w* was unknown, the proper spelling of the name of this plant would be "sahuaro" instead of "saguaro."

It would be difficult to estimate exactly the importance of this plant to the animal life of the area which it inhabits. Its flowers, opening in May and June, offer food and shelter to countless swarms of small bees and gnats. The ripening fruits furnish a profusion of seeds and a wealth of sweetish pulp to birds and smaller mammals, while the Indian makes use of both portions of the fruit, fresh, fer-

mented and preserved. Scores of tribal battles have been fought in Papagueria over the sahuaro harvest. The seeds which reach the ground quickly germinate in the baking soil, and the tiny capsules of acid water stored in the plump spineless hypocotyl constitute a most attractive morsel for thirsty and hungry animals, and not one seedling in a million survives the first year, in consequence. The bases of large plants are stripped and gnawed by rabbits and hares in the southern portion of the habitat, while carpentarios, or woodpeckers, bore huge cavities into the soft outer tissue which are quickly lined with a callus formation, forming a fine nesting cavity. These cavities also offer storage room and shelter for swarms of honey bees. With so many animals making use of the fleshy trunk and branches, the greater number of the sahuaros perish before reaching a height of forty feet. The central pith and the thick outer cylinder of pulp quickly decay, leaving a fascicle of woody rods anastomosing in the older lower portions, but free in the upper terminal parts.

The woody skeletons of the sahuaro form a light and strong building material much used by the Papagos in making the picketed walls of their jacales, or barriers around small gardens or corrals. Illustrations of such uses are to be seen in the city of Tucson. Recently, Mr. Fred. C. Wright has discovered a process of dehydration and tanning that will greatly increase the usefulness of the sahuaro. (*Plant World*, May, 1908.)

The opuntias, with flattened stems as well as the cylindrical forms, force themselves persistently on the attention of the traveller in Papagueria, and great discomfort or even serious injury may result from an unguarded encounter with these armed plants. The heavy rigid spines may penetrate deeply into the flesh, and the glochids, which form short tufts at numerous places on the surface and are easily detached, quickly work into the skin with highly unpleasant results. It is to these structures that attention is chiefly directed in the effort to get an opuntia useful for forage and salad. A dozen species spineless, or nearly so, are known; but the breeder must get a form which does not develop the glochids beyond a rudimentary stage, if the most offensive features of the armament are to be avoided.

Some of the cylindrical forms are arborescent, with widely spreading branches. The joints are easily detachable, so that a slight contact causes the spines to pierce the clothing or skin and a joint of the stem comes away bristling with a score of spines and some of these also pierce the flesh. The instructed use a stick or a pair of tweezers to remove the pest. Dogs, horses and cattle reared in cactus regions,

learn to free themselves by a shaking motion. Attempts to remove the detached joints by the fingers are often disastrous.

The ease with which the joints are detached, the facility with which they become attached to animals and the rapidity with which these segments root and form new plants when dropped, make this one of the most important methods of reproduction. This is true especially of *Opuntia mamillata* and *O. fulgida*.

These two forms were formerly thought to be included in a single species, but on all of the expeditions from the Desert Laboratory they have been found easily distinguishable. They offer a marked example of closely allied forms living in the most intimate proximity.

The acid fruits are not set free until they are three years old or even more, in some instances. After the pulp decays, the hard seeds lie on the ground inactive for months or even years, meantime being subject to the action of numerous rodents which gnaw through the hard outer coat to get at the embryo. Both species are known as "cholla," a name loosely used, and sometimes applied to any cylindrical opuntia, although it strictly belongs to a species native to Baja California (*Opuntia cholla*).

A number of rodents fortify their burrows with joints of the cholla which are dragged into such position around the entrances as to allow a crooked passage for the occupants, but which would discourage the marauding coyote, cat or fox.

The spines and glochids of the cacti do undoubtedly lessen the ravages of grazing animals to some extent, but no ground is afforded for the conclusion that the armature is a direct and purposeful response to the injuries inflicted by animals. The structures in question seem to have been induced by aridity and in a dozen species the evolutionary development has been carried still farther and the spines are reduced to the merest rudiments. Singularly enough, the two poorly armed species, occurring in the vicinity of Tucson, are not seriously molested by animals. It is also to be noted that while the cacti seem to be especially suited for arid conditions, yet many species occur in moist tropical forests.

Two massive forms of melon cacti or biznagas (*Echinocactus wislizeni* and *E. emoryi*) were encountered by our expedition at elevations above a thousand feet in Sonora and Arizona, while a third, with a number of smaller heads in a cluster, was seen nearer the Gulf of California. The larger species often measure over 5 feet in height, with a diameter of more than 2 feet at the base, containing as much as 6 or 8 gallons of water. This sap is only slightly charged with substances ordinarily in solution in the plant-cell, and an Indian

runner, striving to make a swift journey in Papagueria, need not carry water with him, but may resourcefully shape his way to meet these "biznagas," from which a grateful supply of satisfying liquid can be quickly obtained. Some travellers speak slightly of the juice as a drink, and magnify the difficulty of its extraction. It has, however, proved useful on many expeditions, and if the thirsty traveller is so fortunate as to be armed with an ax or a large knife, he may secure a quart of liquid within seven to ten minutes. Lacking these, he must burn away the huge spines and then crush the top and pulp with a stone before the juice can be squeezed with fingers into a centrally made cavity, a method which may need twice as much time, but which might avoid serious consequences from thirst in a region in which a man at work uses as much as sixteen pints of water daily.

Not all melon cacti can be expected to yield their store of water so readily, however. *Echinocactus grandis* attains the height of seven or eight feet and a thickness of a yard in the desert of Tehuacan in southern Mexico. The firm pulp is heavily loaded with lime, so that when chewed it is unpleasantly gritty; the juice is not obtainable by the methods used with the Sonoran species. It is reported, however, that water is obtained from some species in South America by the native Indians.

A general view of the entire region shows that it includes as the principal topographical features a series of minor ranges of mountains trending in a northerly and southerly direction, which have undergone tremendous erosion in a desert climate, with the result that the intervening areas are great valleys or bolsons filled with detrital material brought down from the mountains. The soil is very poor in humus, the drainage is undeveloped, oases of peculiar structure occur, the diurnal changes of temperature are of wide amplitude, the effects of wind erosion are very marked, the precipitation sustains a very low ratio to the possible evaporation, as a consequence of which all areas under 4,000 to 6,000 feet are strongly desert in character. Within the limited areas offered by the higher mountain slopes, much more mesophytic conditions prevail by reason of the greater precipitation and decreased evaporation. In such comparatively humid localities a vegetation of mesophytic forms is encountered, forming islands in this great desert. Also at lower levels there occur a large number of species which carry out their entire cycle of activity during the brief rainy seasons or periods of greatest precipitation, and these do not exhibit any marked xerophilous qualities, except that the dormant seeds or quiescent roots are capable of withstanding great periods of drought without damage.

The greater proportion of the area, however, is occupied by true desert species, which by structure and physiological capacity are well equipped for the arid conditions prevalent. In some, structures which prevent loss of water are most noticeable, while in others, the capacity for the absorption and retention of surplus water during times of precipitation is developed to an enormous degree.

So far as the geological record is to be taken as fairly interpreted, arid conditions have prevailed here since Pleistocene times. No unmistakably xerophilous plant remains have yet been unearthed by the palæontologist, and we are driven to the conclusion that the cacti and other characteristic plants of this region must have originated within the present arid period.

The overshadowing influence of desiccation on development makes it impossible to select any given place as a meeting or mingling point of the forms occurring at the higher level and those native to the coastal region and extending far to the southward.

A number of species are found over its entire breadth from elevations of 3,000 and 4,000 feet in southeastern Arizona to the dunes near the shore of the Gulf, a distance of 200 miles. Among these are to be included *Cercus giganteus*, *Covillea tridentata*, *Encelia farinosa*, *Prosopis velutina*, *Fouquieria splendens* and *Parkinsonia microphylla*, all of which are essentially desert species, showing marked xerophytic structures. Some of these species extend hundreds of miles north and south of the region under discussion, with a total range in excess of the variation of conditions which would be furnished by a vertical mile of mountain slopes. Then a large number of other forms occur in very narrowly restricted areas or pockets, evidently determined by local drainage or moisture conditions, so that an analysis of their inter-relations which would make possible a delimitation of "life zones" is extremely difficult. Thus, in traversing the slopes from 4,000 feet in the vicinity of Tucson to sea-level, the only place where any distinct alteration in the character of the flora may be discerned is at the junction of the lava beds with the gravelly detrital plains, and at the contact of the sand dunes with the playas on one hand, and at the contact of the sand dunes with the Gulf.

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